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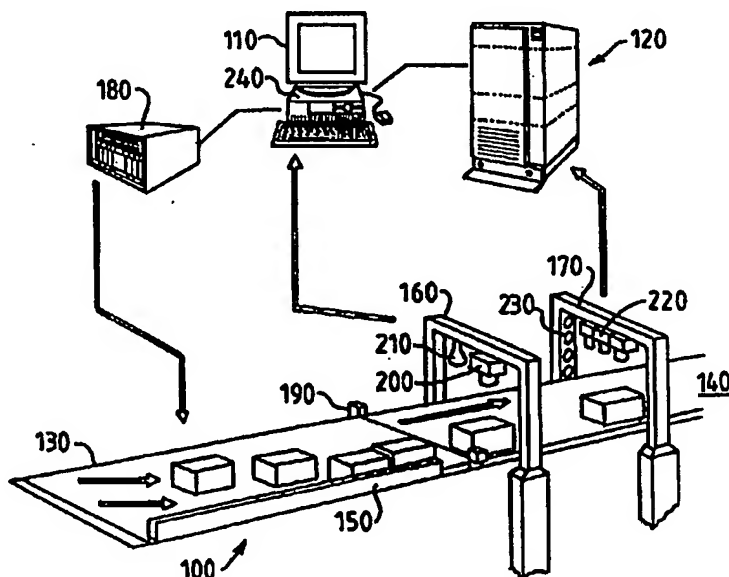**WO 95/24278** (art. 158 de la CBE).

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(54) Title: IMPROVEMENTS IN IMAGE PROCESSING

(57) Abstract

Image processing apparatus is disclosed for locating labels on images of parcels comprising: means to generate and store in digital form an image of the parcel comprising pixels arranged in rows and columns; classification logic for classifying each pixel as either a label pixel, a background pixel or neither, based on the pixel colour; segmentation logic for reclassifying each pixel as either label or background based on its original classification and the classification of pixels in its neighbourhood; and identification logic for identifying the boundaries of regions in which all pixels are classified as label pixels.

IMPROVEMENTS IN IMAGE PROCESSING

Technical Field

The invention relates to computerised mail sorting and, more
particularly, to an image processing method and apparatus for identifying
5   and locating labels on digitized images of parcels.

Background Art

With the ever increasing volume of parcel mail, automating parcel
sorting is becoming of vital importance to post offices around the world
and to the transportation industry in general.

10   Generally, in order to automate parcel sorting, it is necessary to
capture a digital image of the parcel and extract from the image routing
information, such as the destination address. This routing information
may then be used by appropriate apparatus to sort the parcel
appropriately or to generate e.g. a bar code to be printed on the parcel
15   for subsequent use in the sorting process.

However, the label may be located anywhere on the parcel and thus
anywhere in the digital image of the parcel. Generally optical character
reader (OCR) technology will be used to extract the routing information
from a reasonably high resolution image of the label. In order to
20   efficiently make use of this technology and avoid the processing of the
whole of the image of the parcel, it is necessary to locate the label on
the image of the parcel. Once this has been achieved it is only
necessary to process the portion of the image corresponding to the label.

Disclosure of the Invention

25   The object of the invention is the provision of an image processing
apparatus for locating an address label in an image of a parcel.

Two kinds of problems must be solved to perform such label
detection. First, achieving the required speed is very difficult. The
image processing must be performed in real time with currently available
30   technology. Second, the image data is not ideal: the label may be

contaminated by noise, the label may be somewhat transparent and
therefore corrupted by the parcel background, and text may appear both on
the label and on the parcel itself. Moreover, the label may appear
anywhere on the parcel.

5   To solve the above problems the invention enables image processing
apparatus to be provided comprising: means to generate and store in
digital form an image of the parcel comprising pixels arranged in rows
and columns; classification logic for classifying each pixel as either a
label pixel, a background pixel or neither, based on the pixel colour;
10   segmentation logic for reclassifying each pixel as either label or
background based on its original classification and the classification of
pixels in its neighbourhood; and identification logic for identifying the
boundaries of regions in which all pixels are classified as label pixels.

15   The invention is based upon the observations made by the inventors
that almost all parcels have white labels with black text and that no
parcels are as white as their labels. Therefore, colour information may
be used to separate the label from the background.

        The pixels are initially classified as either being in the label,
20   the background or neither. Typically the pixels classified as neither
background nor label pixels will correspond to text on the label or the
body of the parcel or be due to noise. A segmentation technique is then
used to re-classify the pixels as either label or background pixels on
the basis of their context. The segmentation technique can, for example,
25   employ known features of the text, for example the fact that pixels
corresponding to text will not form long runs either horizontally or
vertically in the image. In addition the segmentation logic can make use
of the fact that label pixels can be expected to occur in relatively long
runs and that the occurrence of background pixels in the label is quite
30   rare.

        In one embodiment, the classification logic is arranged to classify
white pixels as label pixels, black pixels as neither label pixels nor
background pixels and all other pixels as background pixels. However
there are other possibilities. For example schemes could be devised
35   which employ labels of a particular predefined colour. In this case, the
apparatus would be adapted to identify and locate labels of that
particular colour from the parcel images. Furthermore, the possibility

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that pixels of more than one colour all be classified as label pixels is
not excluded.

The invention also provides apparatus for extracting routing
information from parcels for subsequent use in sorting the parcels,
5   comprising a camera for capturing parcel images; means to transport
parcels past the camera; the above described image processing apparatus;
means to generate images of parcel labels using the locations of the
regions in which all pixels are classified as label pixels; and means to
extract routing information from the images of the labels.

10   Viewed from another aspect the invention provides an image
processing method for locating labels on images of parcels comprising:
(a)   generating and storing in digital form an image of the parcel
comprising pixels arranged in rows and columns;
(b)   classifying each pixel as either a label pixel, a background pixel
15 or neither, based on the pixel colour;
(c)   reclassifying each pixel as either label or background based on its
original classification and the classification of pixels in its
neighbourhood; and
(d)   identifying the boundaries of regions in which all pixels are
20 classified as label pixels.

Also provided is a method for parcel sorting including the above
steps.

Brief Description of Drawings

An embodiment of the invention will now be described with reference
25 to the accompanying drawings wherein:
Figure 1 is an overall view of a shipping label translation system;
Figure 2 is a schematic diagram showing image processing apparatus;
Figures 3 a,b and c are illustrative of low resolution parcel images.

Best Mode For Carrying Out The Invention

30   The invention is embodied in a Shipping Label Translation System
which extracts shipping information from labels on parcels using image
capture, image processing and optical character recognition (OCR)
technologies.

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The system is illustrated in Figure 1 and comprises the following major components:

(a)   Conveyor system 100, with low and high resolution image capture stations 160 and 170 respectively;

5   (b)   Computer 110 operating under the control of a suitable program providing a user interface, overall system control and image processing functions;

(c)   OCR Subsystem 120;

(d)   Programmable logic controller 180 which enables the computer 110 to
10   control the functioning of the conveyor and the image capture cameras.

Conventional components are used for the mechanical and image capture functions of the conveyor. Whilst modifications are required to handle the labels, the fundamental OCR building blocks, both hardware and software, are also conventional. Computer 110 could, for example, be one
15   of the IBM RISC SYSTEM/6000 family of computers (IBM and RISC SYSTEM/6000 are trade marks of International Business Machines Corporation).

The data flow and major components shown in Figure 1 are explained in the following sections through descriptions of the processing of packages.

20   The conveyor system 100 for the Shipping Label Translation System consists of two separate conveyor modules; an induction conveyor 130 and a process conveyor 140.

The induction conveyor 130 loads packages into the system. Packages are "skewed" to one side of the conveyor along an aligning edge
25   150 as they travel down the belt. This provides a constant location for the packages as they travel through the system. The "skewing" of packages to one side of the conveyor can be accomplished by providing an angled belt conveyor in the horizontal plane, or by providing a decline belt conveyor, in which packages will be transferred to the one side of
30   the conveyor by gravity. The angled horizontal belt is illustrated in Figure 1.

The process conveyor 140 is a continuous running belt conveyor that carries the packages through the two image capture stations 160 and 170.

Conveyor speed control is provided by the Programmable Logic
Controller (PLC) 180. The PLC 180 is connected to and operates under the
control of the computer 110. The control system design provides the
means to select conveyor speeds through options provided by a control
5 program executing on computer 110.

It will be understood that different modes of system operation,
such as maintenance, test, etc., require configurable conveyor speeds.
The controller 180 also monitors a series of photoeyes to track packages
through the system and also provide package "jam" detection. The Gap
10 Photoeye 190 shown in Figure 1 provides feedback for the gap between
packages and act as the gate between conveyor modules.

The operator places parcels on the conveyor 100 one by one with the
labels face up. The operator is not required to rotate the parcel so
that the label is in a fixed orientation.

15   Control over the gap between packages is provided to allow time to
adjust focus of the high resolution cameras for packages of different
heights and the package feed rate to be matched to the image processing
capacity of the system.

To provide this gap, a stop/start conveyor section 130 is used at
20 the package loading point. Packages are released from conveyor to a
constant speed conveyor 140 under control of suitable software in the
computer 110, which monitors the conveyor sensors through Programmable
Logic Controller 180.

The gap mechanism can be used to temporarily stop feeding packages
25 if a delay is required, e.g. for handling rejects. This mechanism could
be eliminated at the expense of reduced throughput by having the
operators place packages farther apart.

The package passes through a stage in which a standard TV camera
200 mounted at a fixed height over the conveyor belt captures a colour
30 image of the top of the package.

Illumination is provided through a strobe light 210 to eliminate
blur from package movement. The camera lens has sufficient depth of

field to handle the range of package sizes required and therefore does
not require focus control.

The TV camera is connected to a video capture board of known type
in the computer 110 and stored in digital form in a storage device in the
5   computer. Suitable software in the computer 110 analyzes the digital
form of the low resolution image to perform the following functions:

(a)   Determining package dimensions and orientation on the belt.
(b)   Label detection.
(c)   Locating an open area on the package for later application of a
10   label.

It is possible to use a number of techniques to determine the
package height from the TV image itself. For example, the length of a
package along the belt path can be measured by a simple photosensor and
contrasted with the length of the package in pixels in the TV image: the
15   package appears longer in the TV image if its top surface is closer to
the camera. Alternatively, the package height could be determined via
discrete sensors, for example, a photocell array looking across the belt,
or sonic sensors mounted overhead on the frame containing the TV camera,
or the like.

20   The package boundaries can be readily determined within the TV
image by detected the colour shift from the package to the belt. Top
surface dimensions and orientation can then be determined. The package
height information is used in conjunction with the top view dimensions to
compute the smallest bounding box that can surround the parcel.

25   The information needed for parcel routing is contained in the
labels of the parcels. In order to facilitate easy access to this
information, computer 110 is programmed to extract the location of the
label from the low resolution images of the parcels.

Labels are located in the low resolution images of the parcels
30   through analysis of their colour differences compared to the parcel
background. In this embodiment, the location and orientation information
is used to define the areas for which high resolution images are captured
downstream.

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In this embodiment, parcels can be processed by the system at the rate of one per second, or 3600 per hour. This processing includes image capture, label detection, rotation detection, de-skewing, and OCR or manual extraction of routing information from the label images. In order
5   for all these operations to be completed image capture and label detection should not take longer than 200ms.

Two kinds of problems have been solved to perform such real time label detection at reasonable cost with currently available technology. First, achieving the required speed is very difficult, since transferring
10   image data from the image capture board to the host for processing takes more than 200ms. Second, the image data is not ideal: the label's white color may be contaminated by noise, the label may be somewhat transparent so the parcel background corrupts the white color, and the black colour of the text on the label is not exclusive to the label. Moreover, the
15   label may appear anywhere on the parcel.

The processing of the low resolution parcel image proceeds as follows.

The TV camera 200 generates a 640 x 480 pixel image. Every 10th line in this image is transferred from the video capture card to the
20   computer memory totalling approximately 50ms. This results in a significantly subsampled image, but in reasonable time.

To solve the detection problem, a function has been found that estimates the likelihood of every pixel in the image to be in the label. A one dimensional segmentation algorithm is then employed on each of the
25   two major axes of the image to obtain a clear distinction between the label and the rest of the parcel.

This technique is described in more detail below.

The processing of the subsampled parcel image is shown schematically in Figure 2. First, a classification 400 is carried out.
30   The pixels in the image are classified into three classes: Label, Background and Neither. Each pixel is first classified as one of these, disregarding its neighbours.

(a)   Label type pixels: These are the white pixels. It is assumed that
       although such pixels may occur anywhere on the parcel, they are
       concentrated in long runs (both horizontally and vertically) in the
       label area.

5 (b)   Neither type pixels: These are the black pixels. It is assumed
          that such pixels can occur both in the label area and in the
          background area, but in the label they do not form many long runs
          either horizontally, or vertically, or both.

(c)   Background type pixels: All the other pixels. It is assumed that
10   the occurrence of such pixels in the label is quite rare.

The classification 400 consists of two stages:

(a)   Colour space transformation:
       The original RGB image is transformed to YUV image, where Y is the
       luminance component and U, V are the chrominance components. The
15 transformation equations are the following:

$$Y = 0.299 * R + 0.587 * G + 0.114 * B$$
$$U = B - Y$$
$$V = R - Y$$

(b) Colour classification:
20   In the YUV space gray levels are designated by low values of the
       chrominance components (U, V). Among these colours, white colors are
       defined by high values of the luminance component, Y, and black colours
       by low values.

          For each pixel, the chrominance components are first checked. If
25 at least one of them is high, the pixel's colour is not grey and it is
       classified as Background. If both components have low values the
       luminance value is checked. If it is high, the pixel's colour is white
       and it is classified as Label. If it is low, the pixel's colour is black
       and it is classified as Neither type pixel. Pixels having middle range
30 values of luminance are also classified as Background.

          Subsequently, a segmentation process 410 is applied first to each
       row, and then to each column. This process segments the row/column to
       Label, Background, or Neither regions, subject to constraints on the

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region measures. As a result of the segmentation, pixels are re-classified to the categories above, but this time the surrounding context is taken into account. In Figures 3a, 3b, and 3c, 0 designates Label (white pixels), 1 designates Background pixels, and 2 designates Neither
5   type pixels.

Figure 3a shows the pixel classification before segmentation.

Figure 3b shows the classification after row segmentation. Figure 3c shows the classifiaction after column segmentation. In this embodiment, it was assumed that the segmentation constraint is that a run
10   of pixels of any type should be at least three pixels long.

2.   Segmentation. The segmentation logic used in the preferred embodiment of this invention is described below.

The algorithm processes an array of symbols A(). Three symbols are used representing two properties of interest (the '1' and '0' symbols) -
15   in this case the background pixels and the white pixels respectively - and a lack of both (the '*' symbol) - in this case the black pixels.

A() is produced by the classification process, which is not 100% correct. The segmentation process relies on the assumption that in the 100% correct classification of pixels the symbols do not occur isolated,
20   but rather in runs.

The segmentation logic scans A(), and maintains three hypotheses as to the type of run that is reflected by A(). Each of these hypotheses has a score, and when the score of a hypothesis is higher than an experimentally determined threshold, that hypotheses is accepted and
25   forms the output.

Specifically, each hypothesis has the following variables:
Type:- 0, 1, or *;
Score:- representing the quality of match between the segmentation result and the data in A();
30   Run_score:- representing the quality of match between the last segmented run and the corresponding elements in A();
Increment:- the increment to the score if the next element in A() matches the hypothesis type;

Start:- the index in A() in which a run of the hypothesis type is
assumed to have started;
Prev_len:- the length of the last run of this type.

Let A() be a(0) .. a(n-1). The processing proceeds as follows:

5   1. Initialize:
```
score(0) = run_score(0) = increment(0) = start(0) = prev_len(0) = 0;
score(1) = run_score(1) = increment(1) = start(1) = prev_len(1) = 0;
score(*) = run_score(*) = increment(*) = start(*) = prev_len(*) = 0;
current_state = 2;
```

10 2. Loop on steps 3 to 7 for all A() elements:
```
for i in (0..n-1)
```

    3. Score buildup and previous length maintenance:
```
for each hypothesis x in (0 1 *)
        if  (a(i) matches x)
```
15
```
        (
        if  (increment(x) == 0)  prev_len(x) = 0;
        increment(x) = increment(x)+1;
        score(x)      = score(x)+increment(x);
        run_score(x) = run_score(x)+increment(x);
```
20
```
        }
        else
        (
        if  (increment(x) != 0)  prev_len(x) = increment(x);
        increment(x) = 0;
```
25
```
        }
```

    4. Starting point update

```
for each hypothesis x in (0 1 *)
        if  (a(i) matches x and start(x) < 0)  start(x) = i;
```

    5. Hypothesis acceptance

30
```
y = MaxArg( score(x), x in (0 1 *) }
if  (run_score(y) > threshold(y))
        (  .
```

```
      current_state = y;
      for j=start(y); while j<=i; j=j+1
      a(j) = y;
      break;
5       }
```

6. Normalization

```
      if (current_state != * && a(i) != *)
            increment(*) = increment(1-current_state);
            if (run_score(current_state) > threshold(current_state))
10          run_score(0) = run_score(1) = run_score(*) = 0;
```

7. Score Tracking

```
      for x in (0 1 *)
      if (increment(x) == 0 && score(x) < score(current_state))
            (
15          score(x) = score(current_state);
            run_score(x) = 0;
            start(x) = -1;
            }
```
8. End of Loop

20   The term 'a(i) matches x' in the above algorithm includes the case
where a(i) = * and also the case where a(i) != current_state, and
increment (a(i)) < prev_len(x) for x != a(i).

        It will be understood that it is possible to subsample the image in
many ways other than at every tenth line as in this embodiment. It is
25 also possible to vary the sampling density according to observed Label
type pixels: a high sampling density in the vicinity of such pixels, low
density elsewhere.

        A by-product of the label detection analysis is the identification
of the featureless areas on the parcel top surface, one of which is
30 reported as the open area for application of the label.

        The package next passes through a stage in which high resolution
(200 DPI grey scale) images of the label areas are captured, using

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standard 2048 element line scanners 220. Since the field of view for a
single line scanner is approximately 10 inches (2048/200 DPI), two
alternatives providing coverage of the overall package width are
possible.

5   (a)   Three line scan cameras, each covering 1/3 of the belt width, with
slightly overlapped fields of view, and each with its own lens. With
this arrangement, the number of "candidate" labels is not limited by the
scanner configuration. This configuration, however, requires a software
"stitching" operation to be performed on label images which are split
10   across two scanners.

(b)   Multiple line scan cameras which pivot to look at a 10 inch area
containing candidate labels. Two cameras guarantee that images from any
two candidate labels can be captured regardless of label location.
Additional candidate labels within the same 10 inch swathes can also be
15   covered. Pivoting the cameras introduces some predictable image
distortion that software must compensate for.

With either approach, a motor-driven focus adjustment is provided
for the camera lens, to compensate for different package heights.

Illumination for the line cameras is provided as a continuous strip
20   of light 230 across the belt.

The 200 DPI 4-bit grey scale image for each label is passed to the
OCR Subsystem 120 from the appropriate scanners based on knowledge of the
positions of the labels obtained from the low resolution images.

The high resolution label images are processed by OCR subsystem 120
25   in a known manner to extract routing information from the text printed on
the labels.

Finally, the routing information can be forwarded to an application
that will apply a label with a mechanism further downstream on the
conveyor system.

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Industrial Applicability

The invention can be applied to the field of computerised parcel sorting apparatus including image processing apparatus for identifying and locating labels on digitized images of parcels.

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CLAIMS

1.   Image processing apparatus for locating labels on images of parcels comprising:

5   means to generate and store in digital form an image of the parcel comprising pixels arranged in rows and columns;

       classification logic for classifying each pixel as either a label pixel, a background pixel or neither, based on the pixel colour;

       segmentation logic for reclassifying each pixel as either label or background based on its original classification and the classification of
10   pixels in its neighbourhood; and

       identification logic for identifying the boundaries of regions in which all pixels are classified as label pixels.

2.   Image processing apparatus as claimed in claim 1 wherein the segmentation logic is arranged to identify runs of pixels in a linear
15   array of pixels which should have the same classification, to determine whether all pixels in the run should be classified as label pixels or background pixels based on the classifications of the pixels therein and to reclassify the pixels in the run not classified as label pixels or background pixels accordingly.

20 3.   Image processing apparatus as claimed in claim 2 wherein the segmentation logic is arranged to process the image row by row and then column by column or vice versa.

4.   Image processing apparatus as claimed in claim 1 wherein the classification logic is arranged to classify white pixels as label
25   pixels, black pixels as neither label pixels nor background pixels and all other pixels as background pixels.

5.   Image processing apparatus as claimed in claim 1 comprising a camera for capturing the image.

6.   Image processing apparatus as claimed in claim 5 comprising means
30   to subsample the image generated by the camera.

15

7.   Apparatus for extracting routing information from parcels for
subsequent use in sorting the parcels, comprising a camera for capturing
parcel images; means to transport parcels past the camera; and image
processing apparatus comprising: means to receive a signal from the
5   camera and generate and store in digital form an image of the parcel
comprising pixels arranged in rows and columns; classification logic for
classifying each pixel as either a label pixel, a background pixel or
neither, based on the pixel colour; segmentation logic for reclassifying
each pixel as either label or background based on its original
10   classification and the classification of pixels in its neighbourhood; and
identification logic for identifying the boundaries of regions in which
all pixels are classified as label pixels; means to generate images of
parcel labels using the locations of the regions in which all pixels are
classified as label pixels; and means to extract routing information from
15   the images of the labels.

8.   Image processing method for locating labels on images of parcels
comprising:
(a)   generating and storing in digital form an image of the parcel
comprising pixels arranged in rows and columns;
20   (b)   classifying each pixel as either a label pixel, a background pixel
or neither, based on the pixel colour;
(c)   reclassifying each pixel as either label or background based on its
original classification and the classification of pixels in its
neighbourhood; and
25   (d)   identifying the boundaries of regions in which all pixels are
classified as label pixels.

9.   Method for parcel sorting comprising transporting parcels past a
camera; generating and storing in digital form an image of the parcel
comprising pixels arranged in rows and columns; classifying each pixel as
30   either a label pixel, a background pixel or neither, based on the pixel
colour; reclassifying each pixel as either label or background based on
its original classification and the classification of pixels in its
neighbourhood; identifying the boundaries of regions in which all pixels
are classified as label pixels; generating images of parcel labels using
35   the locations of the regions in which all pixels are classified as label
pixels; extracting routing information from the images of the labels;
and sorting the parcels using the routing information.

FIG. 1

CLARIFICATION	400
SEGMENTATION	410
IDENTIFICATION	420
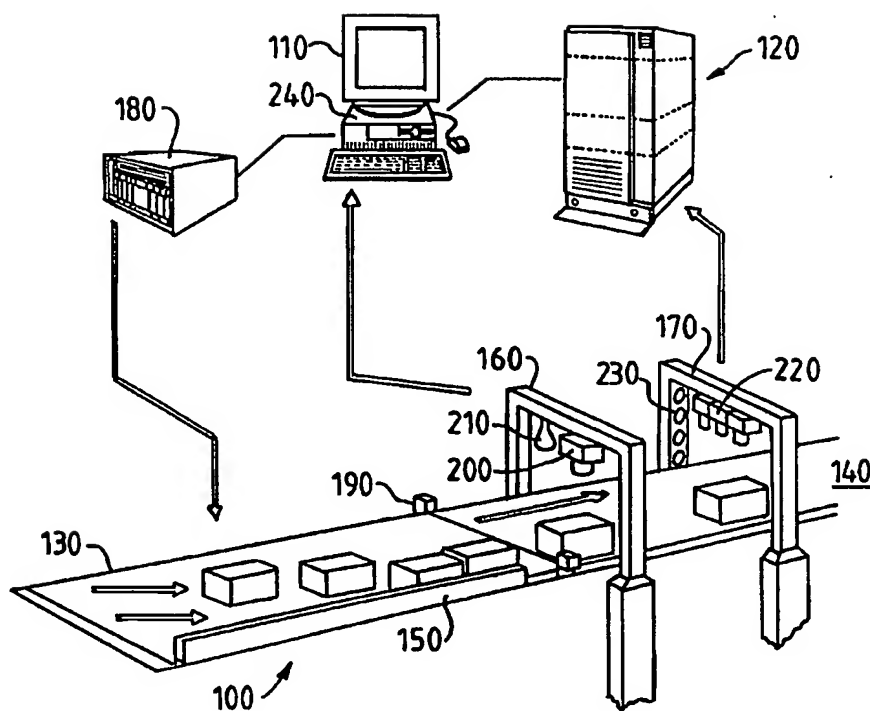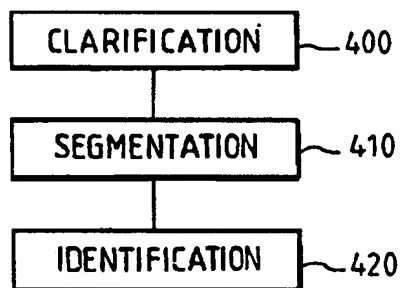
FIG. 2

2/2

```
First Classification
--------------------
11111111111111111111
11110000000000011111
11110020202200011111
11110000000000011111
11110022202200011111
11110000000000011111
11110001000000011111
11111111111111111111
11111111111211111111
11111101111111111111
11111111111111111111
11111111122111111111
11111111111111011111
11111111111111111111
```

FIG. 3A

```
After Row Segmentation
----------------------
11111111111111111111
11110000000000011111
11110000000000011111
11110000000000011111
11110022222200011111
11110000000000011111
11110000000000011111
11111111111111111111
11111111111111111111
11111111111111111111
11111111111111111111
11111111111111111111
11111111111111111111
11111111111111111111
```

FIG. 3B

```
After Column Segmentation
-------------------------
11111111111111111111
11110000000000011111
11110000000000011111
11110000000000011111
11110000000000011111
11110000000000011111
11110000000000011111
11111111111111111111
11111111111111111111
11111111111111111111
11111111111111111111
11111111111111111111
11111111111111111111
11111111111111111111
```

FIG. 3C

INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER

IPC 6   B07C3/14

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 6   B07C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	DE,A,39 42 932 (LICENTIA PATENT-VERWALTUNGS-GMBH) 27 June 1991 see the whole document	1-3,5-9
A		4
Y	9TH INTERNATIONAL CONFERENCE ON PATTERN RECOGNITION, vol.1, 14 November 1988, ROME, IT pages 27 - 31, XP000042756 DOWNTON ET AL 'Pre-processing of envelope images for optical character recognition' see the whole document	1-3,5-9

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
11 November 1994	28.11.94

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Forlen, G

INTERNATIONAL SEARCH REPORT

Intern. .onal Application No

PCT/EP 94/00667

Patent document cited in search report	Publication date	Patent family member(s)		Publication date
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